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MONITORING OF THE ECOLOGICAL CONDITION OF THE ENVIRONMENT

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***Abstract**: The paper presents the basic tasks and methods of biological monitoring of the ecological condition of the environment, which include bioindication and biotesting. Possibilities of application of living organisms in bioindication research are considered, especially indicator species, which due to their genetic, physiological, anatomical and other characteristics are able to survive in a narrow interval of a certain factor, indicating the presence of that factor in the environment.*

***Key words**: ecology, monitoring, organism, testing.*

INTRODUCTION

Ecological quality of the environment means an integral characteristic of the natural environment, which enables the preservation of health and a comfortable human life.

The natural environment in which we live has been formed over hundreds of millions of years. The modern shape of the Earth and the composition of the basic environments of organisms - soil, air, water - are created and maintained thanks to the life activity and interaction of an inconceivable multitude of living beings (Jemcev, Đukić, 2000; Đukić, Đorđević, 2004). It is artificially impossible to create a quality (full-fledged) environment for a human being. Only in the biotope can the quality of the environment be maintained and regulated - parameters that are necessary for life (temperature, humidity, salt composition,

ratio of gases in the atmosphere, climate). Today, science knows at least $7 \cdot 10^6$ biological species. Scientists believe that this number is only a part of the real diversity of life on Earth.

Since man has adapted[37] and can comfortably survive (live) only in the modern biological environment, in natural ecosystems, the term "ecological quality of the environment" means maintaining ecological balance in nature (relative stability of species composition in the ecosystem and environmental composition), which ensures human health.

It is necessary to distinguish between goals and ways of standardizing and assessing the quality of the human environment based on basic physical and chemical parameters, on the one hand, and ecological forecasts of future changes in ecosystems and human health under anthropogenic stress - on the other.

ENVIRONMENTAL ASSESSMENT

For the overall assessment of the state of the environment and determining the level of participation of certain sources in its pollution, sanitary-hygienic and toxicological norms are applied (maximum permissible concentrations - MAC - pollutants, maximum permissible levels of impact – MPI. However, in order to predict the results of the impact of anthropogenic factors on both ecosystems and human health, it is necessary to keep in mind many other indicators that characterize the reaction of certain organisms and the whole ecosystem to man-made impact (Đukić i sar., 2008, 2012, 2013, 2015, 2018; Đukić, Mandić, 2016).

Reactions of living systems to various chemical and physical factors and their combination are characterized by such features as the integrity and cumulative nature of many influences, paradoxical effects of low doses on animals and plants, the existence of chain processes and certain consequences of local influences on different "floors" complexly organized ecosystems. It is difficult to predict the reactions of human organisms living in conditions of technogenic artificial ecosystems.

Today, it is already common that one of the obligatory conditions for "stable" socio-economic development is the preservation of the natural environment of man and its restoration after destructive influences (Đukić i sar., 2013, 2015).

[37] Adaptation - a set of morphophysiological, population and other characteristics of a given biological species, which ensures the possibility of a specific way of life in certain environmental conditions.

It should be noted that living systems (organisms, their communities and entire ecosystems) have the ability to self-regulate, autopurify and adapt. This is, in part, conditioned by the environmental forecast. Ecosystem stability, for example, depends on the diversity of species, on the interrelationships of the abundance of species, which represent different trophic levels, on the reproductive properties of organisms and the regulation of the abundance of each population with intergenous relationships in the community and abiotic factors.

Environmental hazard, or risk, should be assessed not only on the basis of the character and strength of the anthropogenic impact, but also on the basis of the biological properties of the reacting system. Accordingly, there are two groups of methods of ecological monitoring (monitoring the state of the ecosystem): physico-chemical and biological (biomonitoring). Each method of monitoring has its limitations. For the purpose of qualitative assessment and forecast of the state of the natural environment, it is necessary to combine them. Therefore, physico-chemical and biological monitoring do not exclude, but complement each other.

Anthropogenic pollution affects living organisms, including humans, in various combinations and in a very complex way. Their integral effect can be assessed only on the basis of the reaction of living organisms or entire communities. The prognosis of the impact of polluted water, chemical additives in food or polluted air on humans is valid, if the assessment of toxicity includes not only analytical methods, but also the biological diagnosis of the impact of the environment on animals. In addition, many xenobiotics (foreign substances of the biosphere) accumulate in the body. The result of long-term effects of even small concentrations of these substances are pathological changes in the body. Finally, the paradoxical effect of small doses of many biologically active compounds is known, when extremely low doses (less than the MAC) have a stronger effect on the body than their medium doses and concentrations (Mandić i sar., 2010).

The universal indicator of the change in the homeostasis[38] of the test organism is the state of stress at maturity from a "clean" to a "polluted" environment.

The term "stress" is used very differently in many fields of science. As a scientific term, *Selje* first introduced it to medicine in 1936, and it soon entered everyday language as a sign of non-specific mental tension. *Selje* (1979) defines stress as a reaction to the increased load, which is manifested by the syndrome, which consists of all non-specifically caused changes within the biological system.

[38] Homeostasis - permanence of the internal environment of the organism; homeostatic mechanisms enable adaptation to the environment and preservation of the viability of the organism.

In biology, stress means the reaction of the biological system to extreme environmental factors (stressors), which, depending on the strength, intensity, moment and duration of the impact, can more or less strongly affect the system.

Stress can be divided into two types, which act differently. Eustress is characterized by physiological adaptive reactions, which are caused by bioenergetic processes in the body, when in critical situations the living being must adapt to changed environmental conditions. Distress means pathogenic processes, which usually occur in the case of constant loads or efforts, which the organism is not able to regulate in a short or long period of time. The extent to which a stressor will cause eustress or distress depends on a number of factors, for example, a combination of exogenous stimuli and the internal state of the organism.

The reactivity of an organism to active stressors depends primarily on its genetic constitution. The time factor also plays an important role in the development of stress, which is related to the development of sensitivity to stress, as well as to the duration of the impact of any effective stressor during different periods of life.

The danger of anthropogenic stressors is that biological systems - whether organisms, populations or biocenoses - are insufficiently adapted to them. Anthropogenic stressors are created at such a rate that appropriate adaptation processes often fail to be activated in living systems. Many anthropogenic environmental factors therefore become dangerous stressors. According to the size, intensity, duration and moment of impact, they differ from the "norm" that is usually present in nature, and to which biological systems have adapted. Finally, they often affect the range of tolerance[39], which often leads to exceeding the allowable load on the organism and the breakdown of the biological system.

It is necessary to pay attention to the fact that in nature, not one stressor acts on the organism, but the whole complex of disruptive factors (complex stressful influence of the environment). In doing so, of course, any particular factor may occasionally or permanently dominate. In this regard, it is understandable that the reactions of organisms to stressors in a laboratory experiment do not always coincide with those in natural conditions. Therefore, the examination of the combined action of the environmental load, i.e complex stressful influence of the environment, it is extremely important to determine the allowable load and stability of biological systems in the environment that is disturbed due to the action of many anthropogenic stressors.

[39] Tolerance - tolerance, resilience. The ability of an organism to withstand the adverse effects of an environmental factor.

The stressful influence of the environment leads to the deviation of the basic parameters of the organism from the optimal level.

ENVIRONMENTAL HAZARD ASSESSMENT

The assessment of the degree of ecological danger is traditionally done by determining some potentially harmful substances or influences in the environment and comparing the obtained results with the legally determined (for them) maximum allowed values. At the same time, this method of control has a number of significant shortcomings. Analog methods are, as a rule, demanding, not always fast, they require expensive and sometimes deficient devices and reagents, as well as highly qualified service personnel. Their main disadvantage is that these methods cannot guarantee a real assessment of environmental hazards, if a wide range of analyzed substances is not analyzed, because it is not the levels of pollution and impact that are important, but the biological effects they can cause and cannot provide information and about which even the most accurate chemical or physical analysis cannot provide information.

ECOLOGICAL AND SANITARY-HYGIENIC STANDARDIZATION

Indicators of ecological and sanitary-hygienic standardization (maximum permissible concentrations - MPC, maximum permissible doses - MPD, maximum permissible levels - MPL), which are used in practice, and which are always based on toxicological tests with testing of special biological objects, cannot take into account changes in the toxicity of pollutants due to the effects of synergism or antagonism in the combined action of anthropogenic factors. These norms do not reflect the dependence of the toxic effect of pollution on physical environmental factors, do not take into account the processes of natural transformations of matter in the environment or their disappearance during the detoxification of the environment from specific pollutants. Therefore, along with physico-chemical methods, it is necessary to use methods of biological control and diagnostics - bioindication and biotesting, which provide objective integrated assessments of environmental quality and the basis for forecasting the state of ecosystems (Markert et al., 2003; Wolterbeek, 2002, Mandić i sar., 2021).

Biological methods of environmental quality control do not require prior identification of specific chemical compounds or physical influences. They are

quite easy to implement, many are express, cheap and allow for environmental quality control in a continuous mode. At the same time, after determining the total toxicity of soil or water samples, the application of analytical methods follows in order to determine its causes. Traditional physico-chemical methods also make it possible to assess the participation of certain companies or other sources of pollution in the integrated technogenic effect on nature.

An integrated assessment of the quality of the environment is proposed to: determine the state of bioresources, develop a strategy for rational use of the region, determine the maximum allowable burdens for the region's ecosystem, solve the fate of areas with intensive industrial and agricultural exploitation contaminated with radionuclides, etc.; detection of ecologically poor zones; resolving the issue of construction, commissioning or suspension of a certain company; evaluations of the effectiveness of measures for nature protection, introduction of treatment plants, modernization of production, etc.; applications of new chemicals and devices; raising recreational and protected areas (Đukić i sar., 2008, 2013).

Technical pressure, as a consequence of the scientific and technical revolution, has conditioned the problem of "balancing" the results of anthropogenic impact on the environment as one of the most important tasks of nature protection. Fulfilling this condition is the only way for humanity to survive.

ENVIRONMENTAL ASSESSMENT BASED ON BIOLOGICAL MONITORING

Realization of the basic principles of stable development of civilization in modern conditions is possible only in the case of the existence of appropriate information on the state of the environment, in response to anthropogenic impact, which is obtained during biological monitoring. Environmental quality assessment is a key task of any measures in the field of ecology and rational use of nature. The very term "monitoring" (from the English word monitoring - control) means taking measures of continuous observation (monitoring), measuring and assessing the state of the environment. A complex approach to biological monitoring (combination of bioindication and biotesting methods, use of facilities at different levels of the organization), systematic monitoring, allows to judge the prospects of changing community structure, population productivity and ecosystem stability in relation to anthropogenic factors.

The objects of monitoring are biological systems and the factors that affect them. Simultaneous registration of anthropogenic impact on the ecosystem and biological response to the impact based on the totality of all indicators of living systems is desirable (Holt, Miller, 2010; Najera et al., 2002). Multifactor analysis is necessary, with the inclusion of the most typical anthropogenic influences (for example, chemical substances), as well as changes in natural environmental factors, the level of which changes due to anthropogenic influence. First of all, the biodiversity of species and the composition of coenosis species are taken into account. It is also important to record possible changes in natural populations, for example, disruption of embryonic development and symmetry of adult individuals within the population. It is necessary to discover the rapid "response" of organisms or populations and the results of lasting consequences, because part of the changes can be brought to order by the biosystem.

Examples of the application of bioindication and biotesting methods in the practice of ecological expertise of natural water basins and sources for drinking water supply show that the threshold concentrations of chemical pollutants, which disrupt the vital activity of biotestorganisms, are below accepted MAC values. The constant presence of pollutants, even in low concentrations, leads to a reduction in the diversity of hydrobiont species due to the extinction of species that are most sensitive to water quality. Such changes in biocenoses are determined by bioindication methods - by determining the index and indicators of saprobicity (Mohapatra, Mohamtry, 1992; Đukić, Ristanović, 2005).

A parallel study of health indicators of large groups of people living in polluted areas and using polluted water and agricultural products, reliably shows a reduction (compared to the regional average) in life expectancy, increased overall and premature mortality, and human morbidity, weakening of the immune system, liver and other organs.

The basic principle of biological monitoring is to determine the optimal - control - level, and any deviations from it indicate a stressful impact. Usually, in the case of estimating the optimum of some of the parameters, the question arises as to whether the given conditions will be optimal for other properties of the organism. However, if the examined parameters characterize the basic properties of the organism as a whole, then it is shown that their optimal level is similar. For example, completely different and, so to speak, completely independent parameters, such as asymmetry of morphological properties, blood parameters, oxygen consumption intensity, growth dynamics and frequency of chromosomal aberrations, can change synchronously when the most general baseline changes under a certain stress, feature of the organism - homeostasis of development.